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(54) **Security marking**

(57) A method of identification and/or security marking which comprises applying to or incorporating into an article one or more triboluminescent phosphors and wherein a similar article to be tested may be subsequently subjected to means for stimulating triboluminescence and wherein emission of triboluminescent radiation serves to identify or confirm the authenticity of the test article. In Figure 1, means 5 stimulates the luminescence eg by styli, blades, wheels, scrapers, rotating brushes, bending, or rotating flails. Sight detector 7, eg photodiode and circuitry 8 provide an indication eg light 9 of authenticity. If the triboluminescent material is applied in bar-code format, then an apparatus like that in Figure 1 may be used to detect it. The identification and/or security may be used on or in bank-notes, cheques, securities, credit/charge cards, passports, identification cards, classified documents, packaging and tickets.

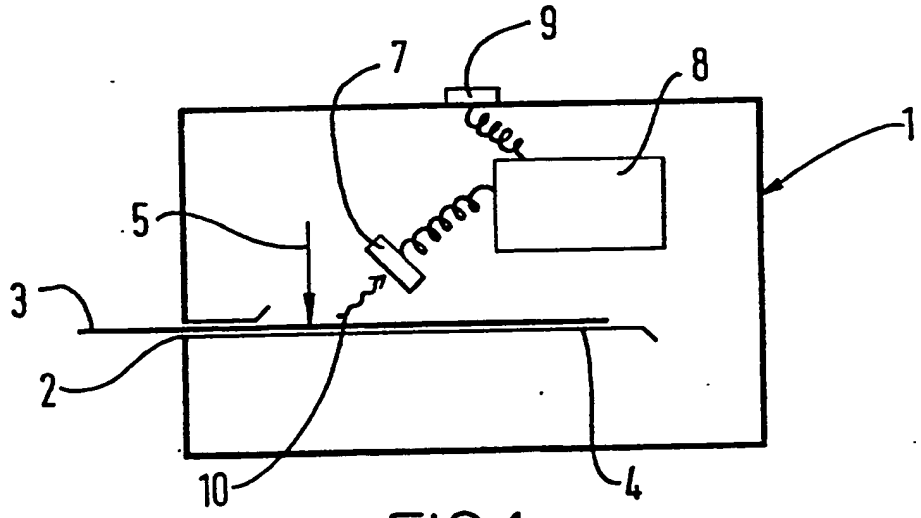

FIG.1

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At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

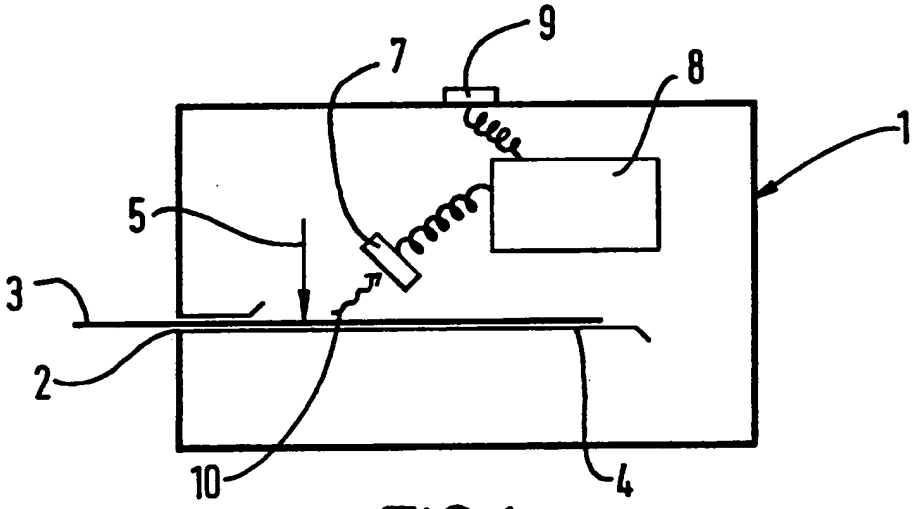

FIG.1

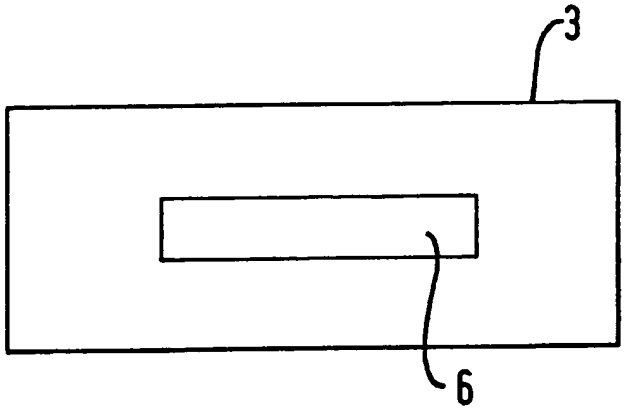

FIG.2

Security Marking

This invention relates to a method of marking articles for identification and/or security purposes.

Many different methods for marking articles are employed for identification/security purposes, e.g. to positively identify an authentic article in the fight against crime such as fraud and counterfeiting. In some applications it is also desired to mark articles so that they can be positively identified by machine. Examples of identification methods which have been employed include the incorporation of holographic images in plastic credit/charge cards and the use of so-called "smart" cards which incorporate electronic circuitry on microchips.

It is also known to mark articles with especially prepared inks and the like for security purposes. For example, it is known to mark articles with phosphorescent and/or fluorescent materials (hereinafter referred to generally as "phosphors") which emit light of a particular wavelength, usually in the visible spectrum, when illuminated by excitation radiation, usually ultra-violet (UV) light. It is also known to incorporate phosphors into, for example, bank-note paper to provide some protection against counterfeiting. Thus, for example, in the preparation of paper for bank-notes it has been the practice for some banks to incorporate pulp fibres in which a proportion of the fibres have been treated with a phosphor. The random incorporation of the treated fibres in the paper shows a distinctive pattern when bank-notes made from the paper are examined under UV radiation.

Exisiting techniques for security marking, for example as described above, generally require the use of sophisticated, and therefore expensive, apparatus for applying and/or reading the marking.

We have now devised a technique for marking articles for security and/or identification purposes which is simple and very economical. Our new method involves the use of triboluminescent phosphors.

Triboluminescent phosphors are materials which emit light as a result of mechanical action. Whilst not wishing to be bound by theory, it is understood that the rubbing together or breakage of particles of a triboluminescent material causes the necessary energy stimulation to produce the phosphorescent emission of light. For example, a triboluminescent phosphor will emit light when the phosphor is subjected to frictional forces, e.g. by rubbing, scraping, scratching, abrasion or brushing, or by pressure such as after impact, or even when subjected to mechanical forces under bending.

Trioboluminescent phosphors have hitherto been generally regarded as a scientific curiosity and very few practical applications have been suggested for their use.

As indicated above, we have now found that triboluminescent phosphors may be used in a very simple and economical method of marking articles for security and/or identification purposes.

Thus, in accordance with one aspect of the invention, there is provided a method of indentification and/or security marking which comprises applying to or incorporating into an article one or more triboluminescent phosphors and wherein a similar article to be tested may be subsequently subjected to means for stimulating triboluminescence and wherein emission of triboluminescent radiation serves to identify or confirm the authenticity of the test article.

In another aspect, the invention provides apparatus for the identification of desired articles or the differentiation of counterfeit articles from authentic articles where the desired or authentic articles have been marked with or incorporate one or more triboluminescent phosphors, which comprises means to stimulate triboluminescence on a test article when a triboluminescent phosphor is present in or on the test article, means to detect the emission of triboluminescent radiation thereby to identify the test article or to confirm or deny the authenticity of the test article, and preferably means to indicate when the emission of triboluminescent radiation has been detected.

In a further aspect, the invention provides an article having applied thereto or incorporated thereinto, one or more triboluminescent

phosphors so that when said article is subjected to a security checking or identification operation in which mechanical force is applied to the article emission of triboluminescent radiation will take place, whereas application of a mechanical force to a similar article not having a triboluminescent phosphor applied thereto or incorporated thereinto will not cause emission of triboluminescent radiation.

The invention can be used for identification and/or security marking of many different articles such as bank-notes, cheques, negotiable securities, credit/charge cards, passports, identification cards, classified documents, packaging (e.g. for high value goods) and tickets. The invention is particularly useful for marking tickets, e.g. sports and lottery tickets, and especially bus, rail, subway or air transport tickets. The invention is thus particularly useful for marking articles where a simple, cheap and fast security checking operation is desired, although it may also be utilised in more sophisticated operations, as discussed below.

The triboluminescent phosphor(s) may be applied to articles in accordance with the invention, for example, by applying an ink or paint incorporating the phosphor(s). As indicated above, it is also possible to incorporate the phosphor directly into the article during its manufacture. Thus, in the preparation of articles such as tickets, bank-notes, cheques, passports, cards and the like, the triboluminescent phosphor(s) could be applied by coating with a suitably formulated ink or the triboluminescent phosphor(s) could be added during the manufacturing process for the article. Preferably, however, the triboluminescent phosphor(s) are formulated as inks or paints and applied to the article by printing. Often, articles such as identification cards comprise a sheet of paper or plastics material having printed matter thereon laminated between sheets of clear plastics material. In the preparation of such articles in accordance with the invention, it is convenient to apply the triboluminescent phosphor(s) when printing the inner sheet.

Preferred embodiments and features of the invention are

described below with reference to the accompanying drawings, in which:-

Figure 1 schematically shows an embodiment of apparatus according to the invention; and

Figure 2 shows an article, in the form of a ticket, in accordance with the invention.

The embodiment of apparatus in accordance with the invention shown in Figure 1 comprises a substantially light-tight box 1 having a ticket slot 2 in one face thereof. The slot 2 is dimensioned to enable a ticket 3 to be inserted into the box 1 but at the same time not allowing very much ambient light to enter the box 1. The ticket 3 is supported in the box by platten 4.

An authentic ticket 3 has printed thereon a strip 6 of triboluminescent phosphor-containing ink (see Figure 2), whereas a forged ticket would not have such a strip. Means 5 are provided in the box 1 to apply a mechanical force to the ticket 3 when the latter is inserted into the box 1. In particular, the means 5 applies the mechanical force generally in the area 6 where the ink containing the triboluminescent phosphor has been applied. The means 5 comprises means to stimulate emission of triboluminescent radiation when a triboluminescent phosphor is present on a ticket inserted into the box 1. Means 5 may comprise, for example, one or more styli, blades, wheels, scrapers, rotating brushes, bending means or rotating flails.

When a triboluminescent phosphor is present on the ticket inserted into the box 1, stimulation by means 5 causes emission of triboluminescent light 10. This may be detected by the light detector 7, e.g. in the form of a photodiode. Any signal from the detector 7 may be processed by circuitry schematically shown by reference numeral 8. The detection of triboluminescent radiation may be indicated by audible and/or visible means, e.g. by illumination of an indicator light 9.

The ticket 3 shown in Figure 2 incorporates a single continuous strip 6 of triboluminescent phospor. It will be appreciated that more than one strip of phosphor could be applied to the ticket or the strip may be

interrupted one or more times, e.g. to form a bar code-like arrangement. If a bar code-like strip is present on the ticket, insertion of the strip into the apparatus may cause a series of pulses of triboluminescent radiation to be emitted corresponding to the bar code. These pulses may be detected by the detector 7 and the circuitry 8 could incorporate means to identify the bar code from the pulses detected.

It will be appreciated that the apparatus shown in Figure 1 is very simple and could be manufactured very cheaply. It is also possible to manufacture apparatus according to the invention without the need for any moving parts and this may give rise to enhanced reliability.

In use, the apparatus of Figure 1 in accordance with an embodiment of the invention could be placed at a convenient location to check the authenticity of a ticket. For example, if the apparatus is to be used for checking railway tickets or the like, the apparatus could take the form of a hand-held authentication device e.g. for use by a ticket inspector or similar. Such devices can be manufactured very cheaply and can be lightweight and easily portable. In a more sophisticated arrangement the device could be located at a platform barrier or could be incorporated into automatic barrier means. On a bus, the apparatus could be located near the entrance platform, for example. At a sports stadium or theatre, the apparatus could be located in or on a turnstile or at the entrances to the auditorium respectively. As each passenger or spectator has his ticket inspected or passes the barrier, turnstile or the like, the ticket will be inserted into the apparatus in order to check its authenticity. A forged ticket not incorporating the triboluminescent phosphor would not produce triboluminescent radiation when inserted into the apparatus and this could be used, for example, to activate an audio/visual alarm or to prevent an automatic barrier being opened.

While the invention has been described above in relation to tickets, it will be appreciated that it may be applicable in many different applications where security checking and/or identification of documents is

required. For example, a credit/charge card could be prepared having the triboluminescent phosphor incorporated therein or printed thereon and apparatus in accordance with the invention could be located adjacent to (or form part of) for example, a cash register or automatic bank teller.

For identification purposes, it may be convenient to apply different triboluminescent phosphors to different articles, or to apply the phosphor(s) in different patterns (for example as bar codes) on different articles. By appropriate incorporation of appropriate means for stimulation of triboluminescent emission and/or appropriate arrangement of detectors in the apparatus, it would be possible to distinguish between different articles. For example, if, say, one type of ticket was printed with a triboluminescent phospor emitting light of one colour whereas another class of ticket was printed with a triboluminescent phospor emitting light of a different colour, the apparatus of the invention could, say, incorporate a plurality of detectors each having an associated filter or being associated with a prism, diffraction grating or the like so that each detector was sensitive to only one light colour. By detecting light of the appropriate colour, the apparatus could distinguish between the articles.

The method of the invention can be further refined, and therefore made more difficult for an attempted counterfeiter to overcome the security markings, by a number of different techniques. For example, it is possible to "mask" the areas where the triboluminescent phosphor had been applied to the article by overprinting with an appropriate ink formulation. For example, the presence of the triboluminescent phosphor could be disguised by overprinting with a UV absorber-containing material; in this way, it would be very difficult for a person seeking to check whether a triboluminescent material was present on the article by examining it under a UV lamp. The UV absorber could be applied in a clear or pigmented film over the triboluminescent phosphor.

In another example of a more sophisticated embodiment of the invention, the desired or authentic articles could be marked with or

incorporate one or more triboluminescent phosphors for which the ratio(s) of intensities of light emission at a plurality of preselected points or bands of the emission spectrum thereof have been determined when subjected to triboluminescent stimulation. A similar article to be tested may then be subsequently subjected to triboluminescence stimulation and the ratio(s) of intensities of light emission of any triboluminescent phosphor on or in the similar article can be determined at two or more of the preselected points or bands of the emission spectrum, and the ratio(s) of intensities determined for the test article are compared with the predetermined ratio(s) of intensities for corresponding points or bands of the emission spectrum. In this way, the test article can be identified or its authenticity confirmed or denied.

Phosphors, including triboluminescent phosphors, exhibit an afterglow or persistence in emission after removal of the stimulation energy source. The rate of decay of this afterglow with time is characteristic of any particular phosphor. The invention may include means to measure the afterglow properties (such as intensity and colour changes with time) of any triboluminescent phosphor present on articles to be tested in order to seek to confirm the presence of a particular triboluminescent phosphor and thereby add a further check for the authenticity of the test article.

Examples of triboluminescent phosphors which may be used in accordance with the invention include zinc sulphide phosphors doped with manganese. The properties, e.g. the emission colour or emission efficiency, of such ZnS:Mn triboluminescent phosphors may be modified by the inclusion of one or more other materials, e.g. tellurium, copper, chlorine, cadmium, mercury or compounds containing them. A typical triboluminescent phosphor which may be used in accordance with the invention includes a ZnS:Mn phosphor sold under the trade name Lumilux CD 135 by Riedel-de Haën, Seeize, Federal Republic of Germany. Other triboluminescent phosphors which may be used in accordance with the

invention include calcium phosphate phosphors doped with dysprosium ($Ca_2P_2O_7$:Dy), and zinc fluoride phosphors doped with manganese (ZnF_2:Mn).

As indicated above, the phosphors are preferably applied to articles in accordance with the invention as inks.

Examples of suitable ink compositions for use with an offset or lithographic printing process comprise, for example, the phosphor(s) together with a conventional oil-based lithographic varnish. Such a varnish may contain resins, such as alkyd resins (e.g. an isophthalic modified linseed alkyl such as Alftalat AL766-Resinous Chemicals Limited), phenolic resins (e.g. Kelres 42405 - Lawter Chemicals Co.), and/or hydrocarbon resins (e.g. a neutral aromatic hydrocarbon resin such as Petro-Rez 140 - Lawter Chemicals Co.); driers, such as manganese driers (e.g. manganese octoate); and a solvent such as a high boiling point (e.g. boiling point 260-320°C) petroleum distillate (e.g. Carless 260/290 or 280/320). Typical formulations are set out in the Table below (all percentages are by weight)

TABLE

Varnish Formulation

	A	B
Alkyd resin	20%	30%
Phenolic/hydrocarbon resin	30%	20%
Petroleum Distillate	48%	48%
Manganese drier*	2%	2%

* As 10% solution in solvent

Ink Formulation

	C	D
Phosphor powder	30%	40%
Varnish (A or B)	70%	60%

The ink formulations preferably contain a high concentration of triboluminescent phosphor in order to produce a relatively strong emission of light when subjected to mechanical force. If desired, it may be convenient to apply two or more layers of ink in order to increase the density of phosphor on the article and thereby increase the amount of light emission.

In its simplest embodiments (for example as described in relation to a simple embodiment like that described above for Figure 1), the invention provides a very simple and straightforward method of security marking using very simple apparatus to authenticate marked articles. For example, in contrast with hitherto proposed apparatus for security marking using phosphors, the apparatus in accordance with the invention does not (in the simplest embodiments) require any moving parts nor complicated electronics (e.g. microprocessors), nor uv lamps. It will readily be appreciated that apparatus in accordance with the invention may be made very cheaply and with high reliability. However, where more sophisticated security checking of articles is required, the apparatus may require more sophisticated electronic circuitry and/or moving parts or the like, but it will be appreciated that corresponding levels of security checking can be achieved with simpler apparatus in accordance with the invention than with hitherto proposed apparatus.

CLAIMS:

1. A method of indentification and/or security marking which comprises applying to or incorporating into an article one or more triboluminescent phosphors and wherein a similar article to be tested may be subsequently subjected to means for stimulating triboluminescence and wherein emission of triboluminescent radiation serves to identify or confirm the authenticity of the test article.

2. Apparatus for the identification of desired articles or the differentiation of counterfeit articles from authentic articles where the desired or authentic articles have been marked with or incorporate one or more triboluminescent phosphors, which comprises means to stimulate triboluminescence on a test article when a triboluminescent phosphor is present in or on the test article, and means to detect the emission of triboluminescent radiation thereby to identify the test article or to confirm or deny the authenticity of the test article.

3. An article having applied thereto or incorporated thereinto, one or more triboluminescent phosphors so that when said article is subjected to a security checking or identification operation in which mechanical force is applied to the article emission of triboluminescent radiation will take place, whereas application of a mechanical force to a similar article not having a triboluminescent phosphor applied thereto or incorporated thereinto will not cause emission of triboluminescent radiation.

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